Technical Report Documentation Page

1. REPORT No.
FHWA/CA/TL-84/17

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE
Revegetation of Problem Soils on Road Slopes

5. REPORT DATE
June 1984

6. PERFORMING ORGANIZATION

7. AUTHOR(S)
Douglas M. Parks, Mong X. Nguyen

8. PERFORMING ORGANIZATION REPORT No.
57328-604165

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Office of Transportation Laboratory
California Department of Transportation
Sacramento, California 95819

10. WORK UNIT No.

11. CONTRACT OR GRANT No.
E75TL03

12. SPONSORING AGENCY NAME AND ADDRESS
California Department of Transportation
Sacramento, California 95807

13. TYPE OF REPORT & PERIOD COVERED
Final

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
This work was performed under the Federal Highway Administration Research Project E75TL03, "Mitigation of Highway Related Chemical Water Quality Pollutants"

16. ABSTRACT
A study of the techniques used to revegetate problem soils at three highway cut slopes was made. Topsoil, lime and revegetation treatments were used to neutralize the acidic leachate at two of these sites. The third site contained serpentine soil.

This report describes these mitigation measures and evaluates their effectiveness.

This is the final report for the project entitled "Mitigation of Highway Related Water Quality Pollutants". Other Caltrans studies conducted as part of this research are described in the following reports:

*"A Survey of Measures Used by State Transportation Agencies to Mitigate Chemical Water Pollutants Related to Highway Facilities," Report No. FHWA/CA/TL-80/01, January 1980.

*"Long Term Environmental Evaluation of Paint Residue and Blast Cleaning Abrasives from the Middle River Bridge Repainting Project," Report No. FHWA/CA/TL-82/09, July 1982.

*"Detention Basins at Two Snow Removal Maintenance Stations: An Evaluation," Report No. FHWA/CA/TL-84/11, April 1984.

*"Sediment Basins With Slotted Riser Outlets: An Evaluation," Report No. FHWA/CA/TL-84/12, April 1984.

17. KEYWORDS
Mitigation, water quality, erosion control, leachate, lime treatment, topsoil, vegetation

18. No. OF PAGES:
46

19. DRI WEBSITE LINK
http://www.dot.ca.gov/hq/research/researchreports/1981-1988/84-17.pdf

20. FILE NAME
84-17.pdf

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

84-17
DND

S ... ey, P.E.

P ... , P.E.

Co-Investigator .... D. M. Parks, P.E.

Report Prepared by .... D. M. Parks, P.E.
M. X. Nguyen

RAYMOND A. FORSYTH, P.E.
Chief, Office of Transportation Laboratory

PROBLEM SOILS

SLOPES

E. C. Smith

R. B. Howell

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. FHWA/CA/TL-84/17	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.

4. TITLE AND SUBTITLE

REVEGETATION OF PROBLEM SOILS ON ROAD SLOPES

5. REPORT DATE

June 1984

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)

Douglas M. Parks, Mong X. Nguyen

8. PERFORMING ORGANIZATION REPORT NO.

57328-604165

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Office of Transportation Laboratory
California Department of Transportation
Sacramento, California 95819

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.

E75TL03

12. SPONSORING AGENCY NAME AND ADDRESS

California Department of Transportation
Sacramento, California 95807

13. TYPE OF REPORT & PERIOD COVERED

Final

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This work was performed under the Federal Highway Administration Research Project E75TL03, "Mitigation of Highway Related Chemical Water Quality Pollutants"

16. ABSTRACT

A study of the techniques used to revegetate problem soils at three highway cut slopes was made. Topsoil, lime and revegetation treatments were used to neutralize the acidic leachate at two of these sites. The third site contained serpentine soil.

This report describes these mitigation measures and evaluates their effectiveness.

This is the final report for the project entitled "Mitigation of Highway Related Water Quality Pollutants". Other Caltrans studies conducted as part of this research are described in the following reports:

- "A Survey of Measures Used by State Transportation Agencies to Mitigate Chemical Water Pollutants Related to Highway Facilities," Report No. FHWA/CA/TL-80/01, January 1980.
- "Long Term Environmental Evaluation of Paint Residue and Blast Cleaning Abrasives from the Middle River Bridge Repainting Project," Report No. FHWA/CA/TL-82/09, July 1982.
- "Detention Basins at Two Snow Removal Maintenance Stations: An Evaluation," Report No. FHWA/CA/TL-84/11, April 1984.
- "Sediment Basins With Slotted Riser Outlets: An Evaluation," Report No. FHWA/CA/TL-84/12, April 1984.

17. KEY WORDS

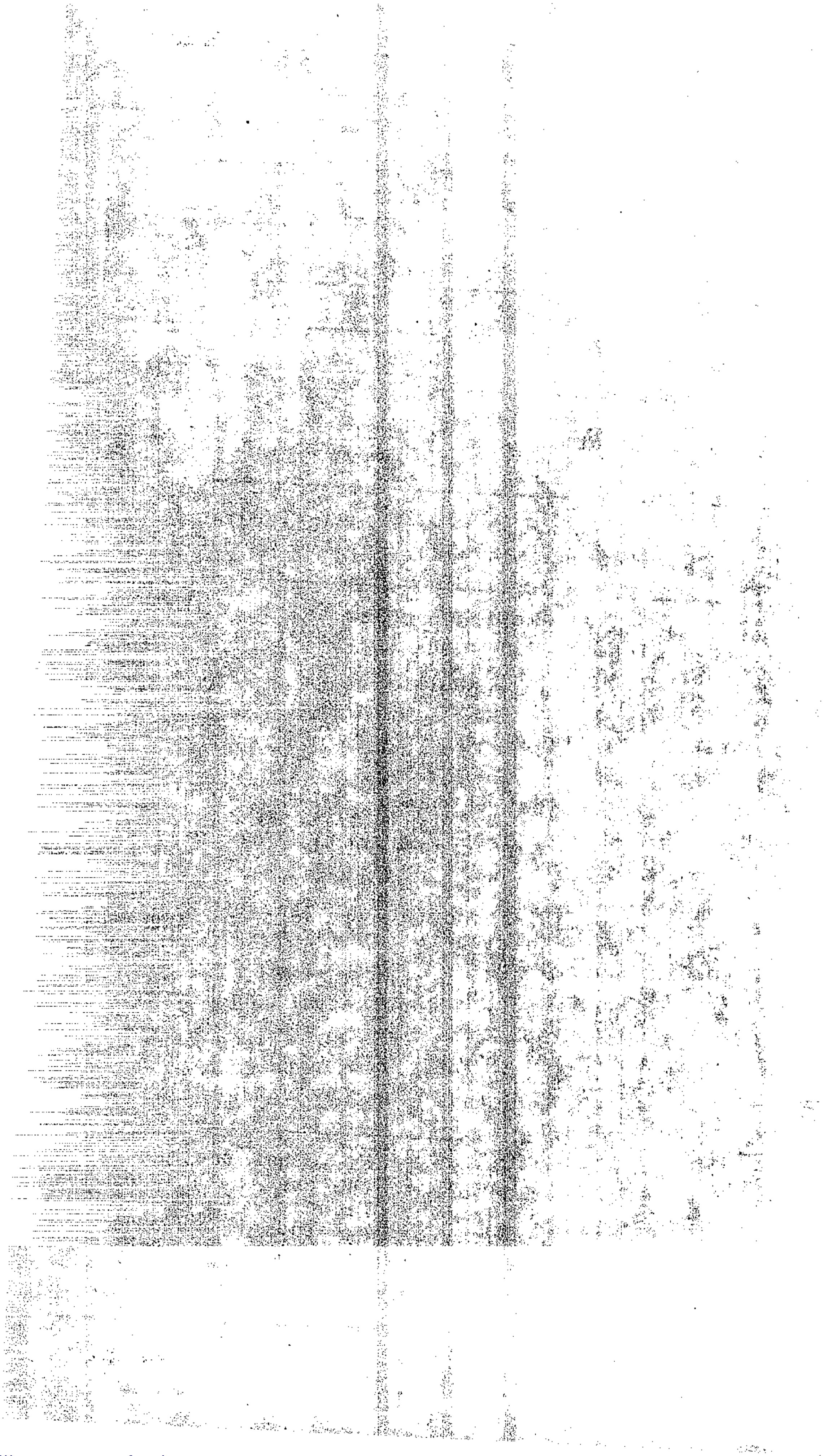
Mitigation, water quality, erosion control, leachate, lime treatment, topsoil, vegetation.

18. DISTRIBUTION STATEMENT

No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. SECURITY CLASSIF. (OF THIS REPORT)	20. SECURITY CLASSIF. (OF THIS PAGE)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified		

DS-TL-1242 (Rev.6/76)



NOTICE

The contents of this report reflect the views of the Office of Transportation Laboratory which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Neither the State of California nor the United States Government endorse products or manufacturers. Trade or manufacturers' names appear herein only because they are considered essential to the object of this document.

CONVERSION FACTORS

English to Metric System (SI) of Measurement

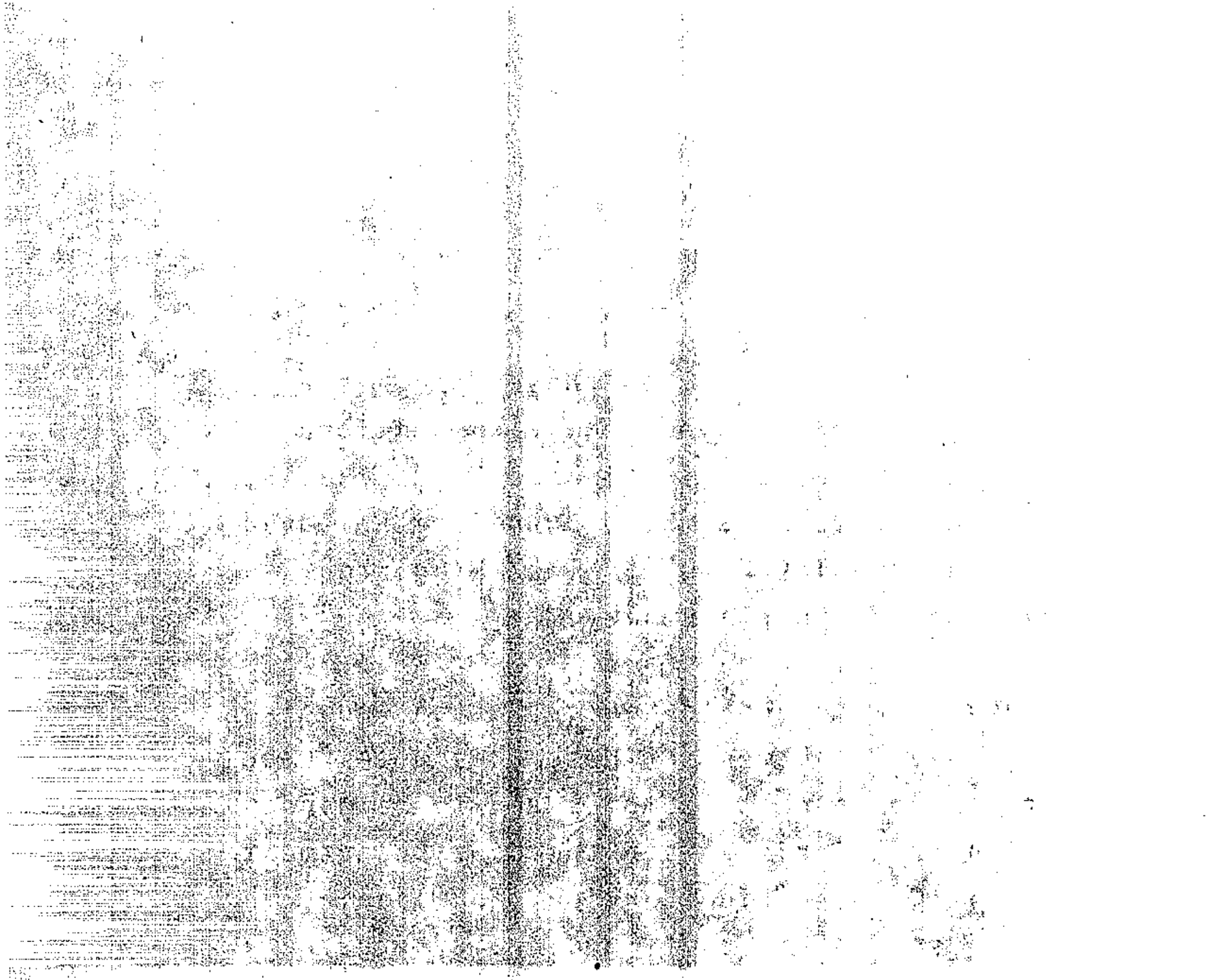
Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mmm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2)	6.432×10^{-4}	square metres (m^2)
	square feet (ft^2) acres	.09290 .4047	square metres (m^2) hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft^3)	.02832	cubic metres (m^3)
	cubic yards (yd^3)	.7646	cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) kips (1000 lbs)	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (ft-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

ACKNOWLEDGEMENTS

The authors wish to thank the following TransLab employees for their contributions during various phases of this project: Don Nakao (former employee, now with California Department of Parks and Recreation), Minh Ha, James Racin, Jeff Gidley, Marty Nolan, James Gamble, Duane Smith, David Smith, Rick Jorgensen, Phyllis Vought, Elmer Wigginton, Irma Howell, Leon Lopez and Darla Bailey.

Also, special thanks is extended to George Gaston and his staff at the California Department of Water Resources Laboratory for analyzing the leachate samples and to Raimond Clary, Jr., Soil Conservationist, with the U.S. Department of Agriculture's Soil Conservation Service, for loaning the hydromulcher to help set up the plots and evaluating the vegetation at the three experimental test sites.

The authors also appreciate the comments provided by Byron Lord of the Federal Highway Administration, Boots Cureton, Jim Jelinek, and Dale Steele of District 10 and the comments from the following Caltrans offices which helped to review this report: Dick Paine, Landscape Architecture; Dick Pryor, Highway Maintenance; and Craig Martz, Environmental Planning.



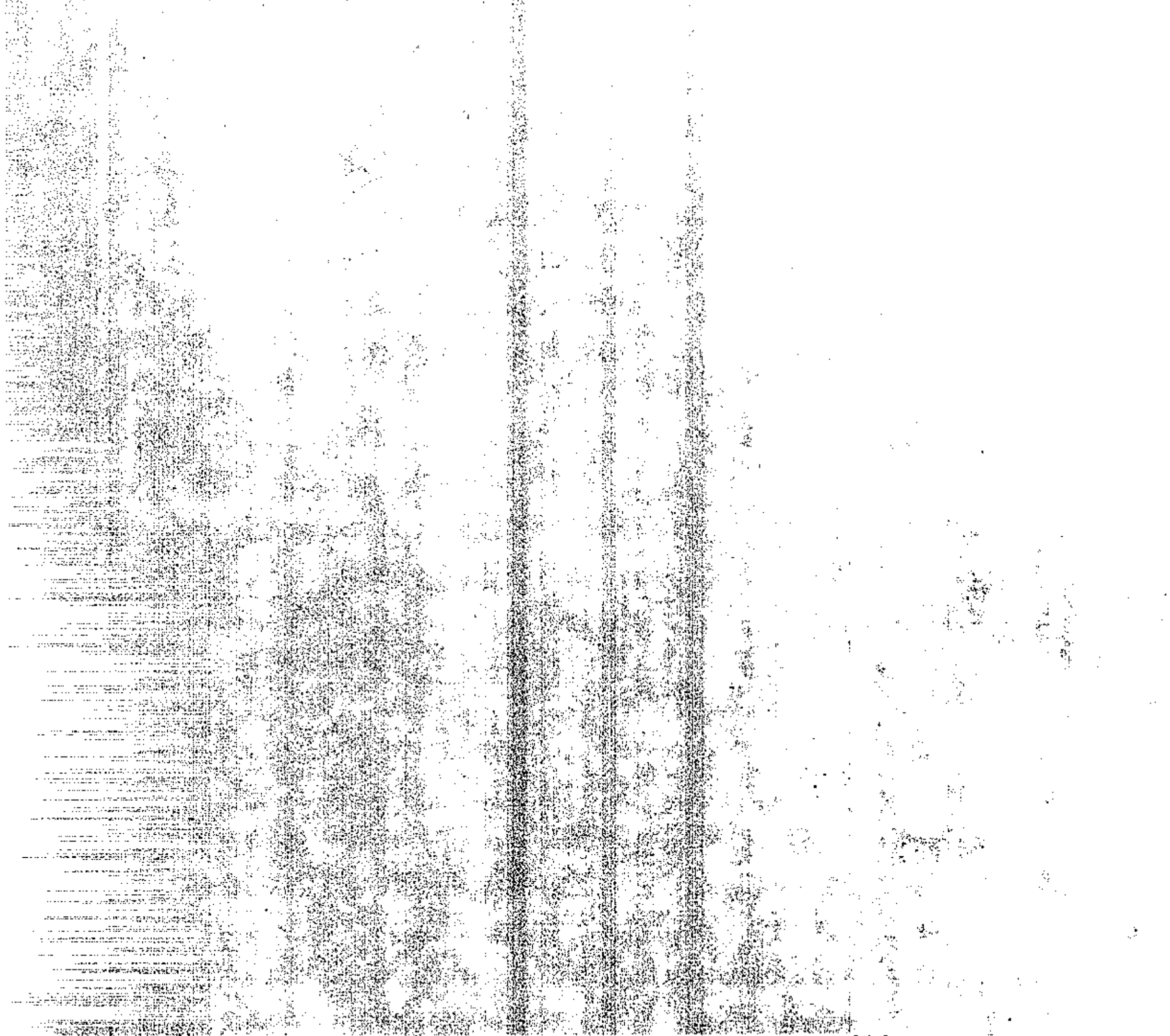


TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF TABLES

LIST OF TABLES (Cont'd)

1. A REVIEW OF THE RESEARCH

Water contamination can result from various sources such as accidental spills, the application of chemicals to roadsides, pavement runoff water containing chemicals, bridge cleaning and repainting debris, and leachates from road slopes where minerals and other chemicals react with rainwater.

A survey of the 50 states was conducted in 1978-79 as part of this research project to determine mitigation measures that were being used. Some of the measures mentioned included detention ponds, sediment basins, hazardous spill cleanup programs, covering reactive soil and mineral slopes with a top layer of neutral soil or burying reactive material inside fill sections, drainage diversions around sensitive water receptors, vegetated waterways to filter material, holding basins or chambers with skimmers and baffles, the use of shrouding to collect sandblast and paint debris from bridge cleaning operations, mechanical water treatment plants, and the use of coffer dams around piers and piling to control polluted water. A discussion of these measures described by the states is contained in the project Interim Report, "A Survey of Measures Used by State Transportation Agencies to Mitigate Chemical Water Pollutants Related to Highway Facilities"(1).

Within California, Caltrans also prepared a report entitled "Best Management Practices For Control of Water Pollution (Transportation Activities)" setting forth procedures to protect water quality(2).

The Caltrans Office of Transportation Laboratory undertook this research project to: 1) Determine those water pollution mitigation measures available for application to transportation problems and to select some for further study, 2) Evaluate the use of the selected measures, and 3) Develop guidelines for the use of these measures.

A number of potential mitigation measures were available to study under Phase III of the research project. Several measures have already been successfully tried such as street sweeping, holding ponds, diversions, etc., and were therefore not considered for further study. Time and manpower constraints precluded undertaking the study of several other measures.

The Office of Transportation Laboratory selected four mitigation measures for in-depth studies.

- Middle River Bridge Cleaning Project
  Mitigation: Use of shrouding and surface boom to contain sandblast and paint debris.

- Detention Basins at Maintenance Stations
  Mitigation: A series of holding basins designed to clarify maintenance yard runoff.

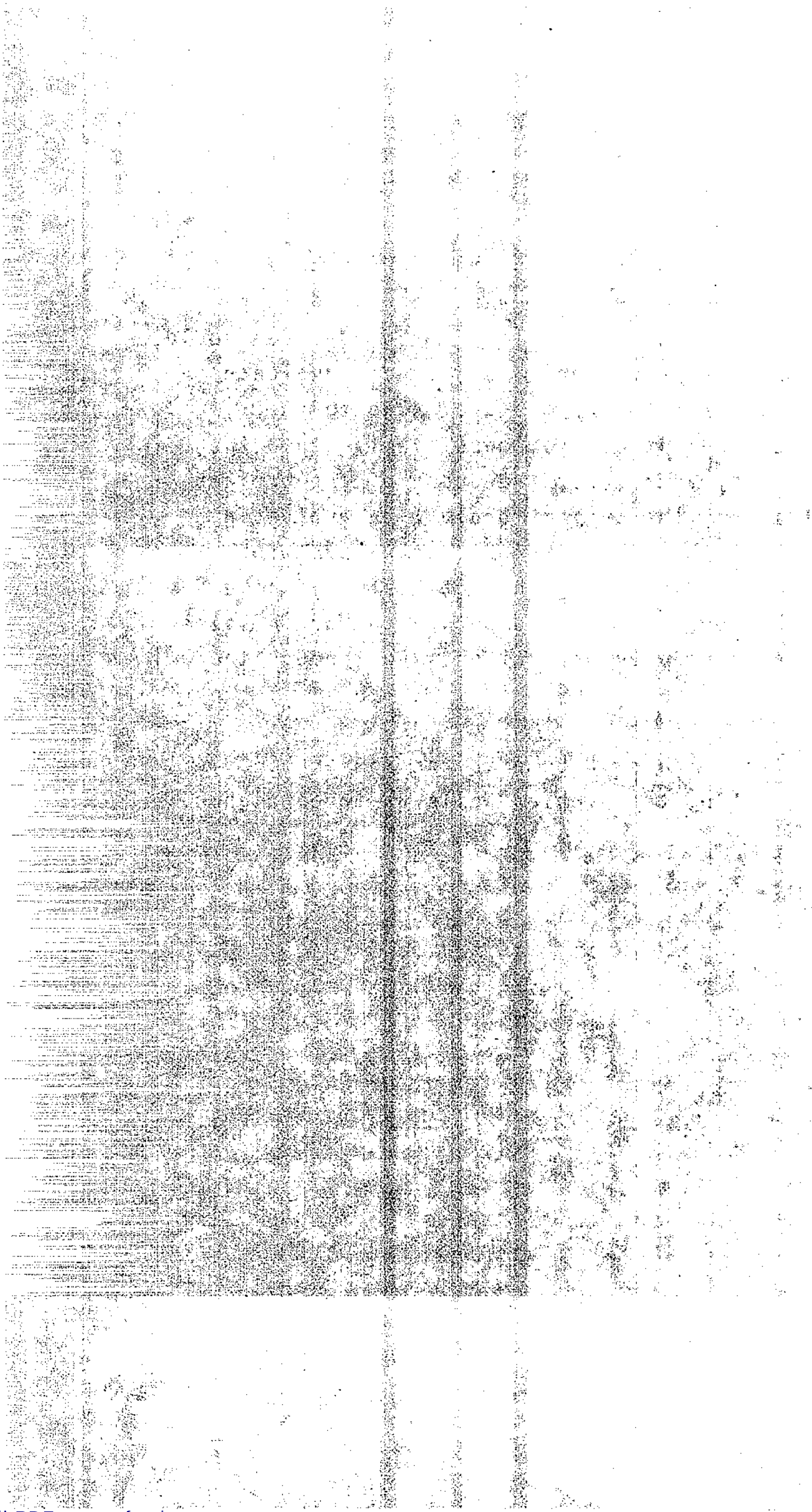
- Grass Valley Creek Sediment Basins
  Mitigation: Slotted pipe risers connected to culvert inlets to form holding basins.

- Chemical Leachates from Exposed Road Slopes
  Mitigation: Revegetation, topsoil, and lime treatments.

The first three studies have been described in Interim Reports for this research project and are cited as references 3, 4 and 5 of this study.

After some preliminary runoff measurements were taken for the Grass Valley Creek project, it was determined that automated runoff sampling and flow monitoring devices would be required in order to get meaningful data to evaluate the effectiveness of the mitigation measure. Due to the remoteness of the site, it was not possible to equip the site as required and, therefore, the scope of the project was changed. Instead, the project dealt with evaluating the effectiveness of the basins for retaining sediment, studying the hydraulic operating characteristics of the basins during storm periods, and comparing the grain sizes of the sediment retained versus that passing through the basins.

The remainder of this report documents the fourth study dealing with mitigating the problem soils at three highway cut slopes.



2. INTRODUCTION

Bare road slopes continue to cause problems for transportation departments. When a road slope loses its vegetation, slope erosion usually begins. Eventually, the accumulated sediment at the bottom of slopes must be cleaned up by maintenance personnel before it flows out onto the roadway, clogs drainages, or gets washed into nearby streams.

In addition to being a maintenance problem, bare slopes are unsightly. Bare, eroding slopes often disrupt the motorist's enjoyment of the many scenic views and vistas experienced along the highway.

The lack of vegetation on the slope may have been caused by a problem soil at the site. The toxic leachate from a problem soil may corrode culverts or impact nearby bodies of water. Measures used to mitigate these problems are often very expensive.

This project focused on revegetating three problem soils in the foothill areas of the Central Valley and in the Coast Ranges near Vallejo. An acidic (pH <4), mildly acidic (pH 5), and an alkaline (pH >9) soil were treated.

The leachate constituents from three highway cut slopes were identified and the effectiveness of various mitigation measures (vegetation, topsoil, and lime treatments) used to correct the leachate problems at these sites are described. Three criteria were used to evaluate the treatments: 1) Whether the treatments significantly reduced the concentrations of the leachate constituents from the slope, 2) The growth and cover of the vegetation used with the treatments, and 3) The erosion control effectiveness of the treatments.

This report represents the final research report for this project.

3. CONCLUSIONS

The following conclusions are based on the evaluation of the chemical leachates from three highway cut slopes and the effectiveness of the treatments used to mitigate the leachate problems at these sites.

No environmental receptors were being impacted prior to the treatments at the three test sites.

Interstate 80 Test Site (10-SOL-80WB, P.M. 9.5)

The leachate from both the upper and lower cut slopes was acidic due to low grade coal (lignite) seams interbedded with the sandstone layers at the site. Prior to the treatments, the minimum pH measurement of the leachate was 3.1. Rainfall at this site averages about 22 inches per year between the months of October and April. The test plot faces east.

The lime and vegetative treatments applied to these slopes significantly raised the average pH of the leachate from the lower slope to 7.2 and the upper slope to a value of 6.7.

Based on the statistical results from both slopes, 75% of the leachate constituents were reduced the first year and 67% the second year.

Evaluations of the vegetation on the test plots showed varied results.

● The grass mix responded significantly to the presence of lime which raised the leachate pH to a neutral level. 'Zorro' annual fescue seemed to be more tolerant of the low pH condition than either 'Blando' brome or 'Berber' orchardgrass.

● First year growth of the annual grasses was good. This growth, however, dropped off the second year allowing the less competitive species 'Berber' orchardgrass (perennial) and rose clover to become more established. After four years, 'Zorro' annual fescue was the only remaining annual grass. 'Berber' orchardgrass and rose clover were also still present.

● There was virtually no growth on the two nontreated control plots seeded with the same grass mixture used for the lime treated plots.

● On a plot receiving only fertilizer, however, 'Zorro' annual fescue seed blew into the plot from an adjacent plot established one year earlier, germinated and grew well for three years. No other grass species became established on this plot.

Route 16 Test Site (10-AMA-16, P.M. 1.0)

This site had a mild acidic condition with a leachate pH, before treatment, of about 5.5. Rainfall at this site averages about 27 inches per year between November and April. The slope faces north.

Both the topsoil and lime treatments, both including vegetation, raised the pH of the leachate. The pH from the topsoil plot was raised from 5.5 to 6.5, while the pH from the lime plot went from a value of 5.5 to 7.1. Both results occurred over a two-year period.

Aside from significant reductions in the electrical conductivity of the leachate, the topsoil and lime treatments did not significantly reduce the concentrations of the metals (Fe, Cu, Pb, Zn or Cd) monitored at this site, which were low to begin with.

Vegetation was effectively established on both the topsoil and lime treated plots as well as on plots receiving no soil preparation or amendments.

- Lack of early growth of annual grasses in the lime plot allowed for vigorous growth of the perennial grass ('Berber' orchardgrass) used in the seed mix.

- The growth of the annual grasses decreased the second year in the topsoil and lime treated plots, probably due to a lack of fertilizer. This reduced competition allowed the perennial grass to become denser in both plots.

- Rose clover was more successful in the topsoil plot the second year due to the lack of competition from the annual grasses and the gradual establishment of 'Berber' orchardgrass in this plot.

- The growth of the grass species in the lime and topsoil plots decreased during the third and fourth years, except for rose clover which continued to increase in both plots.

o The two control plots established without soil preparation or amendments produced good stands of only one annual grass species ('Zorro' annual fescue). These plots were seeded with the same mix used for the topsoil and lime treated plots which included both annual and perennial species.

Route 49 Test Site (10-CAL-49, P.M. 21.6)

The leachate from this site was slightly alkaline and the pH of the leachate ranged from 7.2 to 7.5 for the untreated (control) plot and from 7.3 to 7.7 for the treated plots during a two-year period. The rainfall at the site averaged about 25 inches per year between the months of November and April. The test slope had an eastern exposure.

The vegetation treatments were not effective in reducing any of the leachate constituent concentrations monitored. After one year of growth, both vegetated plots died out, failing to reseed themselves.

Erosion Control Effectiveness of the Treatments

The lime and topsoil treatments (both including vegetation) practically eliminated the erosion occurring at the I-80 and Route 16 test sites. There were reductions in the erosion rates exceeding 90% at both sites. Based on the erosion rates determined from this study, it is estimated that the erosion rates for the I-80 and Route 16 sites, if left untreated, would be 22 tons/acre/year and 30 tons/acre/year, respectively. These erosion rates would be approximately equal to losing 1/4 inch of soil/acre/year at these sites.

Treatment Costs

Based on the Caltrans Contract Cost Data for 1983, it is estimated that the total cost for the topsoil and vegetation treatment (assuming five inches of cover) would range from about $13,800/acre to about $15,000/acre depending on whether the slope is strawed and seeded or just hydroseeded and mulched.

The total cost for the lime and vegetation treatment, based on the same data, would be about $6,900/acre with a lime application rate of 3 tons/acre to about $12,000/acre if 7 tons/acre of lime were applied.

4. RECOMMENDATIONS

As part of the assessment process for potential problem soil sites, the soil pH or the pH of the leachate from the slope should be measured to help determine the severity of the problem. In addition, vegetation adjacent to the site should be identified and considered as possible candidate species for the site. The slope should also be surveyed to determine if there are any signs of erosion or slope instability which may also contribute to the lack of vegetation on the slope.

An economic analysis also needs to be conducted for each potential problem soil site. The cost of the corrective treatment should be weighed against the annual maintenance costs of removing sediment from the site in addition to the costs for repairing any corroded culverts. The proximity of the site to sensitive water receptors should also be considered. If the low pH leachate were to enter a nearby receptor, there may be costs associated with mitigating the impacts.

The following treatments are recommended for reducing the toxicity of the leachate and for establishing vegetation on acidic problem soil sites. These treatments are slight modifications of the ones used for this study and therefore, should be monitored on a few pilot projects before they are accepted for widespread use.

(1) Least Intensive Treatment: Use to establish an early cover of annual grasses.

- Seed: 'Zorro' annual fescue @ 35 lbs/acre
  Rose Clover @ 5 lbs/acre
- Fertilizer: 16-20-0 @ 500 lbs/acre
- Mulch: Woodfiber at 2000 lbs/acre
- Refertilize: 16-20-0 @ 200 lbs/acre every three years until slope is stabilized

(2) Most Intensive Treatment: Use to establish perennial grass in addition to annual grass species. Incorporate a sufficient quantity of lime, determined by soil analyses, into the top three inches of soil to bring the soil pH up to approximately 7.0 or apply a 4- to 6-inch layer of compacted topsoil to mask the problem soil area. Apply the following seed mixture and the fertilizer and mulch at the rates recommended for the least intensive treatment.

- Seed: 'Berber' orchardgrass @ 30 lbs/acre
  Rose clover @ 10 lbs/acre
  'Zorro' annual fescue @ 5 lbs/acre
  'Blando' brome @ 5 lbs/acre

It is also recommended that an alternative method for applying lime to the slope be studied. Perhaps lime could be applied as a slurry with a hydroseeder as a separate step of the treatment. A comparison of the effectiveness of the lime in raising the soil pH by this technique should be made with the method of incorporating the lime into the soil used for this study.

The Offices of Landscape Architecture and Highway Maintenance should review the results of this study, make suggestions for implementing these results, consider further demonstration projects, and look into possible changes to our current specifications.

5. IMPLEMENTATION

Copies of this report will be distributed to the Federal Highway Administration, Caltrans Headquarters Offices, and the 11 Caltrans Districts for their information and future use. The information in this report will be useful for future studies on erosion control, slope revegetation, and mitigation projects involving leachates from highway slopes.

6. PROBLEM SOIL TEST SITES

6.1 Site Descriptions

Three highway cut slopes were selected for this study. The locations of these sites are shown in Figure 1. Table A-1 in the Appendix lists the soil test results for each site.

Site 1 is in the Sierra Nevada foothills on Route 49 in Calaveras County, just north of the intersection of Route 12, at post mile 21.6.

This 2:1 cut slope is approximately 150 feet high, faces east and is at an elevation of about 1000 feet.

At this location, summers are generally warm with a temperature range of 52°F to 86°F, while the winters are cool with temperatures ranging from 32°F to 61°F. Average annual precipitation is 25 inches between the months of November and April.

The slope is composed of two varieties of serpentine rock, a platy variety known as antigorite and a fibrous type called crysotile. Colors range from apple green to dark green. The sheared and foliated rocks are characterized by a greasy, wax-like luster in the massive varieties and silky luster when fibrous.

Small amounts of soapstone and some disseminated pyrite crystals are also present in the serpentine. Chromite is frequently associated with serpentine.

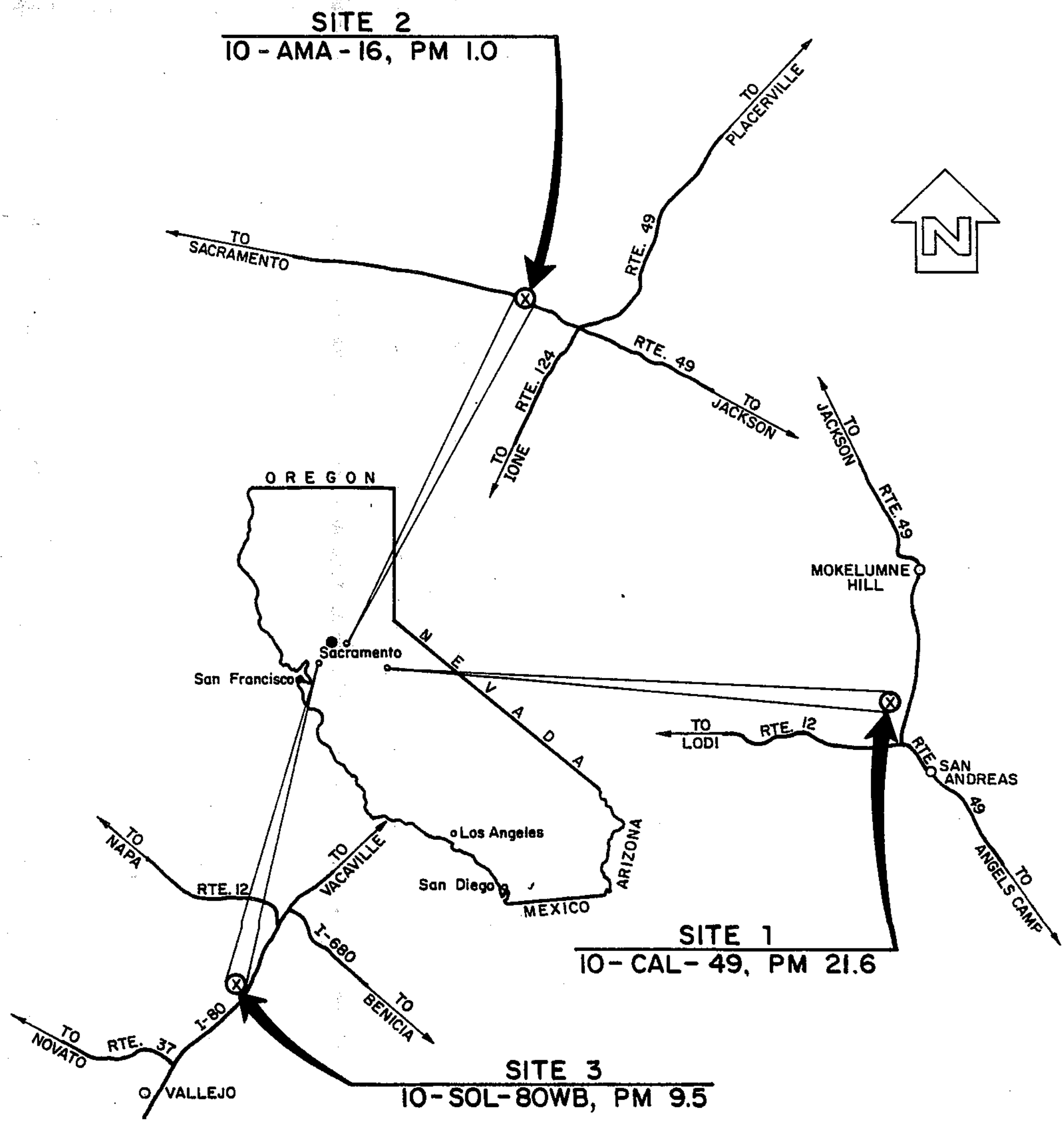


FIGURE 1, Test Site Locations

Because of the extremely sheared and broken nature of the rock, the surface of the cut slope is covered with loose cobble and pebble-sized pieces of weathered serpentine.

The soil is alkaline, having a pH of about 9.5. Soil analyses indicate large quantities of calcium (2533 mg/l), magnesium (82,000 mg/l), and chromium (41.9 mg/l). The soils also contained small amounts of the primary nutrients: 38 mg/l of total nitrogen, 17 mg/l of phosphorous, and 71 mg/l of potassium.

Serpentine soils have always been difficult to vegetate due to their infertility and high magnesium to calcium ratios. There was virtually no vegetation on this slope. The dominant surrounding vegetation consists of annual grasses interspersed with ponderosa pine, digger pine, chamise, buckbrush, toyon, scrub oak and blue oak.

<u>Site 2</u> is located in Amador County on Route 16, one mile east of the Sacramento County line.

This cut slope is about 50 feet high, has a slope angle of 1-1/2:1 (33.7°) and faces north at an elevation of approximately 500 feet.

Temperatures range from a low of 39°F in January to a maximum of 93°F in July. Average annual precipitation is about 27 inches. Heaviest rainfalls occur in December, January and February.

The soils at this location are from the Ione formation of Eocene Age. This formation has been mined for commercial grade clay and glass sand near the town of Ione for many years.

The slope consists of four discontinuous three to five-foot thick lense units of poorly cemented sands and clays which strike northeasterly and dip gently to the north.

The top unit is a buff to yellow, coarse to very coarse-grained poorly cemented quartz-rich sand containing some granule sized (2-4 mm) grains of quartz. Although this angular to subrounded unit is relatively clean, there is a minor coating of clay on the individual grains.

The second unit of yellow-brown medium to coarse-grained clayey sand is quartz-rich, limonite stained and has a matrix of clay. Local lumps of gray sandy clay are also present.

A third unit consists of well-graded, very poorly cemented medium to coarse-grained, quartz-rich sand with a heavy red clay coating. The sand grains are subangular to subrounded.

Lastly, the fourth unit at the bottom of the slope is composed of chalky gray plastic to highly plastic sandy clay. The sand is very fine-grained quartz.

The pH of the soils ranged from 4.3 to 4.9, indicating that this site is acidic. Soil analyses results showed large amounts of chromium (112 mg/l), copper (30.8 mg/l) and iron (10,150 mg/l). There was no calcium. Primary nutrient levels were low: total nitrogen at 57 mg/l, phosphorous at 16 mg/l and potassium at 88 mg/l.

This slope was also heavily rilled and gullied making it unsuitable for plant establishment. There was no vegetation on the slope. The surrounding vegetation is predominantly chamise, whiteleaf manzanita, blue oak, scrub oak and annual grasses.

Site 3 is located in Solano County on westbound Interstate 80 in the American Canyon, about 1.1 miles southwest of the I-80/Route 12 Junction at post mile 9.5.

This benched cut slope faces east, has a slope angle of about 53° and is at an elevation of approximately 300 feet.

Temperatures range from a mean maximum of 80°F in July to a low of about 38°F in January. Average annual precipitation is 22 inches, most of which falls between October and April.

The soils are tannish-gray, fine-grained soft to moderately hard sandstone. Thinner, conspicuous dark colored beds of lignite, characteristically marked by thin limonite layers above and below, are interbedded in the massive sandstone. The sandstone weathers brown due to oxidation of iron-bearing minerals and iron oxide stains.

These soils are acidic, having a pH range of 4.2 to 6.4. The electrical conductivity of the soil was high at 2,600 umhos/cm. The soil contains large amounts of calcium (9920 mg/l), magnesium (740 mg/l), sulfate (501 mg/l), chromium (13.4 mg/l), iron (12,920 mg/l), manganese (115.7 mg/l), and zinc (25.1 mg/l). Primary nutrient levels were low: total nitrogen at 55.5 mg/l, phosphorous at 22.2 mg/l, and potassium at 63.7 mg/l.

There was no vegetation on these cut slopes. The dominant surrounding vegetation is annual grass associated with isolated stands of coyote brush and California buckwheat.

Further evidence of the acidic nature of this site was the corroded horizontal drain pipes protruding from the base of the slope.

6.2 Leachate Sampling

Leachate runoff samples were collected from the three test sites before and after the slope treatments were applied. The first set of samples was analyzed to identify the constituents of the leachate. The results of the second set of samples were used to determine how effective the treatments were in reducing the concentrations of the constituents in the leachate.

Five epoxy coated sheet metal troughs were installed to collect leachate samples at the test sites. One trough was used at the Route 16 and the Interstate 80 sites. A second control trough was installed at the I-80 site when the slope treatments were applied.

At Route 49, however, three troughs were installed. Two troughs were placed under experimental vegetation plots established at the time by the U.S. Department of Agriculture's Soil Conservation Service (SCS). Caltrans had contracted with the SCS to conduct a separate study, a portion of which dealt with determining plant materials for problem soil areas. The third trough at this site was placed above one of these experimental plots to obtain untreated (control) samples to identify the constituents in the leachate. Since the quality of the leachate was not used to determine the SCS experimental vegetation plots, treatments which were thought to have the best chance to succeed were selected for monitoring.

Figures 2 through 5 show the condition of the slopes and the locations of the leachate collection troughs at each test site.

The leachate from the troughs was sampled the day after each storm event. Before samples were taken, however, the leachate was thoroughly stirred and a one liter sample was taken from each trough with a plastic scoop. Approximately one-third of the total sample was collected and emptied into a polyethylene container each time the leachate was stirred.

Initial leachate samples were obtained between December 1979 and February 1980. Route 49 was sampled after eight storms and the Route 16 and Interstate 80 sites were sampled after six storms during this period.

Once the constituents of the leachate were identified and corrective treatments (mitigation measures) applied to each slope, additional leachate samples were taken and analyzed to determine the effectiveness of the treatments. At the Route 16 and I-80 sites, samples were taken during the periods of December 1980 through April 1981 and from October 1981 to January 1982. Additional troughs were installed under the treated plots (#1 and #2 at Route 16 and #2 and #4 at I-80) at these locations.

6.3 Initial Leachate Constituent Concentrations

Tables 1 through 5 present the results of the analyses of the leachate at the three test sites. The chemical tests were performed according to Standard Methods(6) by the California Department of Water Resources Laboratory in Bryte.

Figure 2, Collection Troughs Installed at Route 49

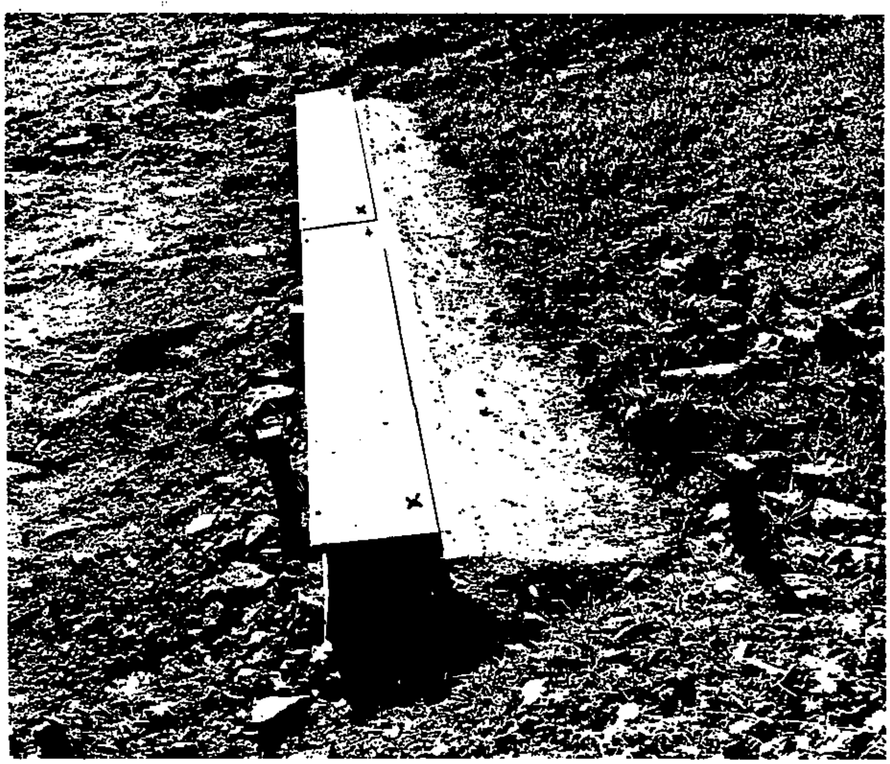


Figure 3, Closeup of 10' Long Collection Trough